Fermilab

PBAR NOTE #458

The new final amplifier system for the H = 84 Accumulator Cavities

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Pbar note xxx

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The final amplifier tubes (3CX10,000U7) where overstressed by the long pulse and cw operation of the last running period. (These tubes where initially applied because they were the only ones available within the timeframe of operational by Sept., 85.) Analysis of four tubes returned to Eimac show damage to the input and output attributible to the long pulse operation. Quoting Eimac, "The pulse operating conditions to which the tube(s) was subjected appear to be the cause (of failure), with pulse widths up to 200 milliseconds." Several other tubes have failed, but have not yet been analyzed by Eimac. With more intense air cooling it might be possible to prevent anode dissipation failures, but it isn't possible to make a 100 microsecond rated input structure reliably operable for 200 microseconds (or CW)!

During the running period in 1985 it became obvious that the 3CX's where inadiquate, and several alternate solutions where proposed. The solution that was chosen was to replace the 3CX10,000U7's with water cooled 3CW20,000A7's which have thoriated tungsten cathodes, and are rated for CW service. Eimac states that the tubes have similiar input characteristics.

The major difference is that the 3CW's will not have the same high peak current capability that the 3CX's had. To get the required power will require operation at higher anode voltage. In other words the 3CW's require a higher load impedance to develope full power. The power that is required is:

P = (V) squared/2*(Shunt Impedance) or (50,000)squared/2*25,000
or 50 Kw/cavity, 25 Kw/tube

The 3CW's should be able to provide this power for the required 200 milliseconds. As the 3CW's must operate into a higher impedance, the coupling to the cavity must be changed. For this reason, several necessary and other desirable design changes have been made.

1. The water cooling to the anode is provided via ceramic tubing insulators.
2. The return water flow will be monitored by 'turbine' flowmeters.
3. The tube maximum pressure rating is 50 psi. Pressure reducers, over pressure rupture disks to drain, and supply solinoid valving will stop flow in event of overpressure. A back pressure booster pump is requireed to satisfy the pressure requirement.
4. The coupling to the cavity is adjustable, by moving the entire assembly of two tubes and coupling loop.
5. The filaments will be operated with DC heating current feed from regulated 'switching' supplies to minimize heater induced ripple.
6. The filament current will be feed to the tube using an inductive coaxial choke, thus the cathode will be DC grounded a quarter wavelength away from the tube.

Provision is being made to monitor each of the two tubes kathode current independently by means of transductors around the 'ground' end of the filament choke. Knowing the drive power from the directional couplers, and the emmission current, the life of the tube can be predicted.

7. Analysis of the cavity Higher Order Mode situation (with 6 rf mode dampers applied) reveals a resonance at 158.7 Mhz. The 3CX's amplifier tubes where operated biased to class C, this operation results in a high harmonic component in addition to the fundamental rf amplifier current. The better cooled 3CW's will allow class AB operation with less excitation of the HOM resonances. The HOM resonances are DQ'd by the Carborundum power resistor in series with the fundamental mode damper. The Z/n is lower than that required for the fundamental, however, the presense of this mode and the class of operation required with the 3CX's may explain the thermal failures of the resistors.
8. The resistor holders have been redesigned to maintain good rf contact at higher temperatures, and also to provide some cooling by conduction of heat away from the resistor.
9. The 3CW's amlifiers will be operated zero bias, eliminating problems associated with bias regulation.
10. The input matching to the tube will be via three parallel 50 Ohm Heliax lines, matching the tubes 15 Ohm input to the 50 Ohm drive lines from the driver.
11. The input of the left and right tubes will be rf shielded from each other.
12. All interlock wiring within the structure will be shielded to prevent rf induced 'interlock satisifying' as previously experienced. Low impedance relay interlocks will be applied.

Enclosures:

A. Front view of cavity showing two 3CW20,000A7's
B. Front detail enphasizing coupling adjustment, water isolator, and filament feed choke.
C. Side view showing limitation on coupling loop travel.
D. Top view with detail of water flow paths.